

Eur J Vasc Endovasc Surg 24, 189–195 (2002)

doi:10.1053/ejvs.2002.1682, available online at <http://www.idealibrary.com> on IDEAL®

## REVIEW ARTICLE

# Vascular Injury Complicating Lumbar Disc Surgery. A Systematic Review

S. Papadoulas<sup>1</sup>, D. Konstantinou<sup>2</sup>, H. P. Kourea<sup>3</sup>, N. Kritikos<sup>1</sup>, N. Haftouras<sup>2</sup> and  
J. A. Tsolakis<sup>\*1</sup>

<sup>1</sup>Department of Surgery, Vascular Surgery Unit, <sup>2</sup>Department of Neurosurgery and

<sup>3</sup>Department of Pathology, University Hospital of Patras, Patras, Greece

**Objectives:** to review the literature concerning the early and late vascular complications of lumbar disc surgery.

**Methods:** using the MEDLINE database, we reviewed all reports of vascular complications associated with surgical excision of a prolapsed disc via a posterior approach reported in the English literature since 1965.

**Results:** we identified 98 cases of vascular complications for an incidence of 1–5 in 10 000 disc operations. Early presentation is shock due to rupture of a large retroperitoneal vessel. Late complications include development of pseudoaneurysms and arteriovenous fistulas. Treatment of a vascular tear consisted mainly of primary suturing of the injured vessel. The preferred method for arteriovenous fistula and pseudoaneurysm repair was suturing from within the arterial lumen along with interposition grafting. Recently, endovascular techniques have been recommended, lowering the high morbidity and mortality related to conventional repair.

**Conclusion:** iatrogenic vascular injury during lumbar disc surgery, although rare, should be suspected if signs of circulatory instability are noted or if lumbar pain, leg oedema or high output cardiac failure develop months to years following such surgical procedures. However, these symptoms may arise during or immediately after surgery, requiring immediate intervention.

**Key Words:** Vascular injury; Iatrogenic injury; Vascular complications; Lumbar disc surgery; Disc herniation.

## Introduction

During the period 1990–2001, 2590 patients were operated on for disc herniation in our institution. Vascular injury was detected in one patient, giving an incidence of 0.04%. The patient presented with postoperative shock due to left common iliac artery disruption. We present a review of the literature regarding vascular complications following lumbar disc surgery, and present our experience.

## Material and Methods

We searched the MEDLINE database since 1965 using multiple combinations of the following search terms: “Disc”, “Lumbar disc”, “Disc herniation”, “Lumbar disc surgery”, “Disc prolapse surgery”, “Lumbar discectomy”, “Vascular injury”, “Iatrogenic trauma”,

“Arteriovenous fistula”, “Pseudoaneurysm” and “Endovascular”. We included all the studies reported in English since 1965, employing a posterior surgical approach. We excluded studies reported in other languages and those with anterior surgical approach.

The types of vascular injury, the clinical presentation and the surgical techniques used in the management of these cases are presented. Information regarding level of disc space pathology, type and site of the injury, symptomatology, method of repair, morbidity and mortality was extracted. Since all of the above points were not addressed in every reference, percentage representation is attained from the available data.

## Results

### Case report

A 55-year-old male was operated on for a symptomatic right-sided disc herniation at L<sub>4</sub>–L<sub>5</sub> and L<sub>5</sub>–S<sub>1</sub> intervertebral spaces, confirmed by magnetic resonance

\* Please address all correspondence to: J. A. Tsolakis, Department of Surgery, University of Patras Medical School, 265 00 Patras, Greece.

imaging. On operation, which was carried out at the knee-elbow position, a routine double discectomy was performed. Neither bleeding nor detectable perforation of the anterior wall of the disc occurred. Shortly after this procedure, the patient developed pallor, tachycardia, hypotension and marked abdominal distention. Emergent laparotomy revealed a large retroperitoneal haematoma created from a 2 cm long laceration on the posterior aspect of the left common iliac artery, about 1 cm distal to the aortic bifurcation (Fig. 1). The haematoma was evacuated and the arterial injury was repaired by excision and interposition of an 8-mm polytetrafluoroethylene graft. The post-operative course was uneventful and the patient remains in good condition 6 years later.

#### Literature review

Including the present case, 99 patients suffered vascular injury as a complication of lumbar disc operation.

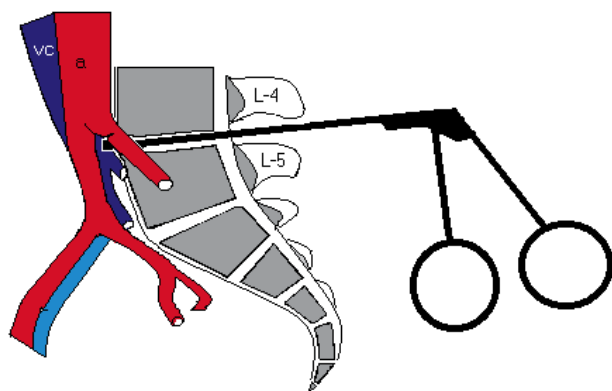


Fig. 1. Direct arterial injury with the pituitary rongeur after performance of the anterior spinal ligament.

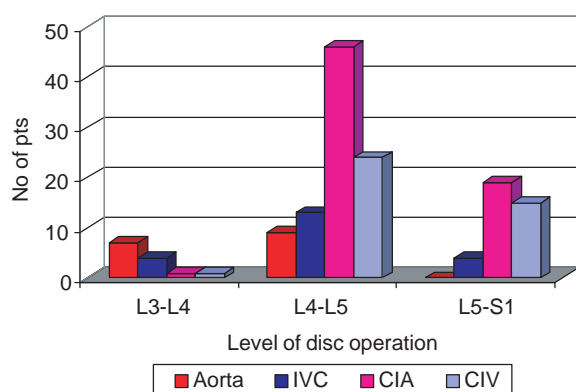


Fig. 2. The incidence of major vessel injury according to the level of disc operation. (The injuries for which the level of the disc operation is not reported and those with more than one discectomies are not included).

The type of injury was laceration in 30 cases (30%), arteriovenous fistula (AVF) in 66 cases (67%), of which 14 cases were combined with pseudoaneurysm, and pseudoaneurysm in three cases (3%) (Table 1).<sup>1-7</sup> We noted that each level of operation was associated with increased frequency for injury of a specific vessel (Fig. 2). Proximal (L<sub>3</sub>-L<sub>4</sub>) level was associated with injuries predominantly to the aorta and the inferior vena cava, while iliac vessel injuries were seen mainly with L<sub>4</sub>-L<sub>5</sub> and L<sub>5</sub>-S<sub>1</sub> space surgery.<sup>5,8</sup> Also injury to L<sub>4</sub> lumbar artery, internal iliac vessels,<sup>5</sup> median sacral,<sup>9</sup> the inferior mesenteric<sup>1</sup> and the superior rectal artery<sup>10</sup> have been described.

The time delay from discectomy to recognition is summarised in Table 2. Generally, lacerations became symptomatic intraoperatively or in the early post-operative period, while arteriovenous fistulas were identified as late as 11 years postoperatively, on average more than a month postoperatively.<sup>6,11,12</sup> Two patients with pseudoaneurysms were diagnosed at 2 and 2.5 years respectively, while the third at the 5th postoperative day.<sup>13-15</sup> Fourteen patients with pseudoaneurysm combined with AVF were diagnosed with a mean time interval of 2.1 years. In two cases (2%) the

Table 1. Vascular injury complicating lumbar disk surgery. \* 14 cases were combined with pseudoaneurysm.

Number of patients	99
Age (range) years	44 (19-75)
Gender	Male 54 (55%) Female 45 (45%)
Reoperative surgery	9 (9%)
Disc level	L <sub>2</sub> -L <sub>3</sub> 2 (2%) L <sub>3</sub> -L <sub>4</sub> 11 (11%) L <sub>4</sub> -L <sub>5</sub> 58 (59%) L <sub>5</sub> -S <sub>1</sub> 28 (28%)
Type of injury	Laceration 30 (30%) A-V fistula* 66 (67%) Pseudoaneurysm 3 (3%)
Site of injury	Aorta 19 (19%) Common Iliac artery Right 43 (43%) Left 29 (29%) Inferior vena cava 21 (21%) Common iliac vein Right 15 (15%) Left 33 (33%)

Table 2. The time interval between the discectomy and recognition of the vascular injury.

Time interval	Laceration	A-V fistula	Pseudoaneurysm
Less than 24 h	28	10	—
24 h to 1 week	2	12	1
1 week to 1 month	—	8	—
1 month to 1 year	—	21	—
Over 1 year	—	15	2
Total	30	66	3

diagnosis of the fatal vascular injury was made at autopsy.<sup>6,16</sup>

The clinical presentations are listed in Table 3. The most common signs and symptoms of vascular lacerations were hypotension (77%), tachycardia, wide pulse pressure, trauma bleeding (53%) and abdominal distention (20%) during or shortly after the operation. Chronic AV fistulas mimic congestive heart failure

**Table 3. Clinical presentation of vascular injuries. Number of patients (%).**

1. Laceration ( <i>n</i> = 30)	
Hypotension	23 (77%)
Trauma bleeding	16 (53%)
Abdominal distention	6 (20%)
Abdominal mass	2 (7%)
2. Arteriovenous fistula ( <i>n</i> = 66)	
Bruit	59 (89%)
Cardiopulmonary problems	43 (65%)
Leg oedema	26 (39%)
Abdominal pain	14 (21%)
Hypotension	15 (23%)
Disc space haemorrhage	14 (21%)
Abdominal distention	7 (11%)
Chest pain	4 (6%)
Pulmonary embolism	4 (6%)
Thrombophlebitis	1 (2%)
Lower extremity varicose veins	2 (3%)
Haematuria	1 (2%)
Renal failure	1 (2%)

accompanied by an abdominal bruit and leg oedema.<sup>17</sup> Late pseudoaneurysms manifested with a new onset of lumbar pain, recurrence of neurological symptoms in lower limbs or gait disturbance.<sup>9,13,14,18</sup> In one patient the pseudoaneurysm was located in the disc space whereas the disc had been excised.<sup>14</sup> Fourteen additional patients (14%) had a pseudoaneurysm coexistent with an AVF and in one of them a pulmonary embolus arising from the false aneurysm entered the venous system via the fistula.<sup>3</sup> Three single AVFs were also responsible for pulmonary embolism.<sup>4,5,19</sup> Thirty patients (30%) were noted to bleed from the disc space during operation, among which 16 had laceration and 14 had AVF.

Ten patients died, giving an overall mortality rate of 10%.<sup>1,6,9,13,16,19</sup> The mortality rate for lacerations was 20% and 38% in case of aortic lacerations. The mortality rate for AVF was 5 and 0% for pseudoaneurysms. The previous reported overall mortality rate was 15–65%.<sup>20</sup> However, we must take into account that fatalities most likely tend not to be published.

The most common surgical techniques for repair of these complications are listed in Table 4. These included techniques of primary suturing, interposition grafting, excision with end-to-end anastomosis,

**Table 4. The various surgical techniques used for repair of the vascular injuries. (IVC: inferior vena cava, CIA: common iliac artery, CIV: common iliac vein, AVF: arteriovenous fistula).**

Laceration ( <i>n</i> = 30)				
	Aorta	IVC	CIAs	CIVs
Lateral suture	3	2	7	5
Graft interposition	3	—	5	—
Patching	—	—	2	—
Arteriotomy-suturing from inside	1	—	—	—
Anastomosis with hypogastric artery	—	—	1	—
Ligation	—	—	—	1
Conservative management	—	—	—	1
(Embolisation of Superior Rectal Artery laceration was performed in one case <sup>10</sup> )				
Arteriovenous fistula ( <i>n</i> = 66)				
Closure of the fistula through an arteriotomy and repair of the artery with lateral suturing or graft interposition				20
Resection of the fistula with primary closure of the vein and an interposition graft to reconstruct the artery				10
Simple division of the fistula and primary closure of the artery and vein				10
Division of the artery, closure of the fistula from the inside and reanastomosis of the artery				9
Simple ligation of the AVF				3
Multiple ligation				2
AVF exclusion procedure				1
Stent-graft				4
Pseudoaneurysm ( <i>n</i> = 3)				
Aneurysm excision with bifurcated graft replacement and anterior interbody fusion				1
Transluminal patching				1
Endovascular repair				1

suturing from within the vessel, patch angioplasty, ligation and endovascular embolisation or stent-graft placement.

## Discussion

Awareness of the types of vascular injury occurring during excision of a prolapsed disc and early detection of these are of importance every time a vascular surgeon is called urgently to handle such a life-threatening lesion.

### Prevalence

The prevalence of vascular complications during lumbar disc surgery is reported to vary between 1 and 5 per 10 000 disc operations.<sup>16</sup> In our series the prevalence was 1 in 2590 consecutive procedures. The first case was reported in 1945 upto 1984 200 cases of simple or multiple vascular injuries had been reported in the world literature.<sup>20,21</sup>

### Risk factors

A vascular injury is not necessarily correlated with poor operative technique during disc removal. A number of factors contributing to increased risk for such injury have been indicated (Table 5). The neurosurgeon must recognise these factors, but even in experienced hands, with none of the former conditions present the threat of vascular iatrogenic injury is present.

### Pathogenesis

The causative process for such an injury is a deep bite with the pituitary rongeur beyond the anterior spinal ligament.<sup>3</sup> Removal of a prolapsed disc is usually

performed in the L<sub>3</sub>–L<sub>4</sub>, L<sub>4</sub>–L<sub>5</sub> and L<sub>5</sub>–S<sub>1</sub> disc spaces via posterior or anterior approach. It is known that the aortic bifurcation and IVC confluence occur at or below L<sub>4</sub> separated from L<sub>4</sub>–L<sub>5</sub> disc space only by the anterior spinal ligament.<sup>22</sup> Thus, a broad vascular bed is formed at this level, vulnerable to injury. Knowledge of the anatomy is essential since the vascular lesion can be identified having in mind the level of the operation, the angulation of the biting instrument and the side of the disc that was evacuated when the bleeding occurred.<sup>29</sup>

The injuries during lumbar disc surgery result in vascular laceration or late complications such as AVF or pseudoaneurysm formation, although the formation of an AVF may sometimes be of acute onset.<sup>20</sup>

Arterial perforation leads to rapid exsanguination. Venous injury if small, may go undiagnosed contributing to underestimation of the prevalence of this complication.<sup>6,30</sup> In addition, it may be aetiologically involved in the development of postoperative deep venous thrombosis (DVT).<sup>5</sup>

Arteriovenous fistula may be formed immediately, if the laceration includes both arterial and venous tear. Arterial haemorrhage evacuates via the venous defect leading to small or absent trauma bleeding or retroperitoneal haematoma.<sup>4,31</sup> Hypotension may also be absent due to the fact that no blood leaves the vascular compartment.<sup>8</sup> The fistula may remain unrecognised for a long time.<sup>32</sup>

Pseudoaneurysms originate from a localised arterial wall disruption.<sup>3</sup> Additionally, partial contusion of a major vessel wall may lead to delayed haemorrhage and/or thrombosis.<sup>9</sup>

### Presentation

Depending on the type of vascular trauma the injury may be immediately recognised or remain undetected for years. Hypotension during or after operation, is indicative of vascular injury and<sup>16</sup> postoperative hypotension with a dropping haematocrit also suggests bleeding requiring exploration.<sup>32</sup> The small rates of trauma bleeding result from a valve mechanism created by the elastic properties of the operated disc that prevent blood leakage.<sup>6</sup> Furthermore, blood leakage from the injured vessels would be expected to take the line of the least resistance into the retroperitoneal space or from an artery to a vein in case of AVF.<sup>16</sup> Abdominal distention is due to an expanding retroperitoneal haematoma and/or paralytic ileus may not be relied upon, as it was found in less than 20% of cases.<sup>28,33,34</sup>

**Table 5. Risk factors for vascular injury during lumbar disc surgery.**

- History of previous disc or abdominal operations leading to adhesions between the retroperitoneal vessels and vertebral bodies.<sup>1,2,22</sup>
- Disruption or degeneration of the anterior annulus fibrosus and anterior longitudinal ligament or peridiscal fibrosis, both associated with chronic disc pathology.<sup>3,23,24</sup>
- Inappropriately deep intrusion of the "pituitary rongeur", which is however required in the presence of advanced disc disease.<sup>25,26</sup>
- Improper positioning of the patient.<sup>3,4,11,13</sup>
- Close proximity between the retroperitoneal vessels and the operated disc, which increases by the pillows placed under the abdomen in the prone position.<sup>2,27,28</sup>
- Vertebral anomalies like hypertrophic spurs may compress the vessels during the operation.<sup>6,29</sup>

Chronic AVF formation should be ruled out in the case of high output cardiac failure and/or lower leg oedema.<sup>35,36</sup> The most common clinical symptom in a patient with AVF is dyspnoea on exertion.<sup>4</sup> Large AVFs lead to CHF, leg oedema and intermittent claudication. Ascites, hepatomegaly and anuria indicate severe cardiac decompensation.<sup>1,37</sup> Scrotal and penile oedema have also been reported.<sup>27</sup> A machinery bruit is noted in the majority of patients.<sup>26,38</sup> A bruit is sometimes heard from significant distance or by the patient himself.<sup>13,26</sup> An abdominal thrill, narrow pulse pressure, diminished femoral pulses and decrease in the ankle/brachial index may be apparent.<sup>22</sup> Associated cardiomegaly is reversed after closure of the AVF.<sup>22</sup> In many cases AVF is simulating DVT or primary cardiac disease.<sup>38</sup> The development of high-output cardiac failure in a young patient, who has recently undergone lumbar discectomy is almost diagnostic of traumatic AVF.<sup>19,39</sup> Although dyspnoea and leg oedema may develop shortly after the discectomy, the diagnosis is sometimes missed and the patient is treated with diuretics.<sup>38,40</sup> Consequently, about 25% of AVFs remain unrecognised even after one year has lapsed. This is attributed to: (a) mild or absent symptoms initially; (b) moderate symptoms attributed to primary cardiac disease, chronic venous insufficiency or DVT; (c) lack of careful physical examination and awareness of this complication and (d) presence of morbid obesity or IVC stenosis which prevent the auscultation of the classic machinery bruit.<sup>16,41</sup>

### Diagnosis

The diagnosis is often rendered through imaging studies. The Doppler technique may provide useful information on systolic pressure and venous flow.<sup>20</sup> Ultrasound duplex examination was performed in 8 patients and intravascular ultrasound in one.<sup>34</sup> Angiography assisted in making the diagnosis and localized the lesion in 65 stable patients with AVF and/or pseudoaneurysm.<sup>33,42</sup> In one unstable patient angiography plus embolisation of superior rectal artery laceration was performed.<sup>10,43</sup> Computed tomography (CT scan), performed in only 17 patients, was diagnostic in one case of delayed AVF, where angiography was not performed.<sup>9,44</sup> CT angiography was performed in 3 patients.<sup>45</sup> Emergent reoperation without any diagnostic examinations was performed in 28 cases. On the other hand, all three imaging studies, U/S, CT and angiography, were employed in an urgent basis to confirm the diagnosis in one case.<sup>46</sup>

### Treatment

The classic surgical repair techniques vary with the type of injury (Table 4).

Aorta and inferior caval vein lacerations were preferably repaired by lateral suturing.<sup>2,24,47,48</sup> This approach is sometimes difficult to perform because the injury is located at the posterior wall. Therefore, suturing from inside after arteriotomy or graft interposition are alternative procedures.<sup>6,9</sup> Large IVC injury is difficult to handle, even with the use of balloon catheters or sponge-stick compression.<sup>3</sup> Ligation may sometimes be necessary and must be preferred to a technically poor venous repair, which is likely to predispose to postoperative thrombosis and pulmonary embolism.<sup>20</sup> However, IVC ligation may lead to chronic venous insufficiency with leg oedema and recurrent cutaneous ulceration.<sup>1</sup> In case of aortocaval fistula the procedure of choice was suturing from inside after arteriotomy or venotomy (in one case) or AVF division and lateral suturing.<sup>31,49-51</sup> Endovascular therapy is also indicated and promising results have already been reported regarding treatment of aortocaval fistulas associated with abdominal aortic aneurysms.<sup>52,53</sup> Repair of late aortic pseudoaneurysm requires excision and primary suturing or interposition grafting or alternatively transluminal patching.<sup>13</sup> Currently, successful endovascular treatment of aortic anastomotic pseudoaneurysms using stent-grafts has been reported.<sup>54,55</sup>

Iliac vessel lacerations were most frequently sutured directly. If suturing leads to arterial stenosis, development of thrombosis is impending and graft interposition or patch angioplasty are the preferred alternatives.<sup>1</sup> In one case thrombosis occurred one month after patch angioplasty and stenosis in another.<sup>26,29</sup> The ureters should be inspected for integrity, because ureteral injuries coincident with vascular lacerations have, in the past, gone undetected.<sup>13,56</sup> If a prosthetic graft is not available, extensive CIA damage could be repaired by means of an end-to-end anastomosis with the contralateral hypogastric artery.<sup>47</sup> Any delay in treatment of arterial lacerations is usually fatal.<sup>6,16</sup> Endovascular treatment with covered-stents is also effective, while lacerations of internal iliac arteries could be managed by endovascular embolisation.<sup>57</sup> In isolated lacerations of iliac veins, lateral suturing was widely used. If suturing leads to venous stenosis, venous patching with autologous saphenous vein patch is indicated for the fear of impending DVT.<sup>20,58</sup> Ligation is reserved for severe vein damage.<sup>10</sup> In one case venous injury was managed conservatively.<sup>6</sup> For iliac arteriovenous fistulas (CIA-CIV or CIA-IVC) the preferred technique

was arteriotomy along with suturing the lumen from inside and graft interposition. Alternative methods included resection of the fistula with primary closure of the vein and reconstruction of the artery by means of graft interposition or end-to-end anastomosis. Additionally, division of the fistula and lateral suturing was also frequently used.<sup>59,60</sup> This was also performed in one case of AVF between the internal iliac artery and vein,<sup>5</sup> while in another case it was complicated by postoperative DVT.<sup>2,27</sup> Simple ligation of the fistula is not indicated for the fear of recurrence.<sup>26,29</sup> In one case delayed amputation was performed due to arterial ischaemia.<sup>61</sup> Concomitant IVC and/or CIV ligation is usually well tolerated, but sometimes may lead to transient leg oedema.<sup>3,4,22,51</sup> To avoid IVC ligation, venous patching was also used.<sup>20</sup> These procedures are sometimes difficult, due to venous dilatation with numerous collateral vessels and severe fibrosis of the operative field.<sup>20,22,27,29</sup> Rupture into an adherent jejunal segment at the suture line and sexual dysfunction are reported complications.<sup>1,2,18,22</sup> The old technique of "quadruple ligation" has been abandoned.<sup>62</sup> Stent-grafts have been recently used.<sup>45,63,64</sup> The lower risk compared to conventional repair of an a.v. fistula, makes endovascular management the preferred option.<sup>64,65</sup> Endovascular management may also be preferable because of patient transfusion refusal for religious reasons.<sup>15</sup> One case of iliac pseudoaneurysm following lumbar discectomy was successfully treated with stent-graft placement.<sup>15</sup> This approach has also been proved effective in the management of iliac anastomotic pseudoaneurysms.<sup>66</sup>

Other injuries: L4 lumbar artery was ligated in one case with L3-L4 and L4-L5 discectomies.<sup>8</sup> For injuries following L5-S1 discectomy the techniques previously described were applied; while ligation of the inferior mesenteric, the median sacral artery or the internal iliac vessels, have also been reported.<sup>1,5,9</sup> Finally, embolisation of superior rectal artery laceration has been achieved by endovascular techniques.<sup>10</sup>

The surgeon who performs discectomy should consider the following precautions:

- Use Shevlin's test. Fill the wound with irrigating saline: if it escapes rapidly through the disc space the annulus and anterior spinal ligament has been perforated increasing the risk of vascular injury.<sup>67</sup>
- Take into account any episode of intraoperative hypotension or bleeding.<sup>1</sup> Perform emergency laparotomy in the unstable patient suspected of vascular injury.<sup>68</sup>
- Auscultate the abdomen before discharge.<sup>11</sup>

- When examining patients with leg oedema /signs of cardiac insufficiency, enquire for history of previous discectomy and have a high index of suspicion of an a.v. fistula.

## References

- 1 BIRKELAND IW, TAYLOR TKF. Major vascular injuries in lumbar disc surgery. *J Bone Joint surg* 1969; **51**: 4-19.
- 2 JARSTFER BS, RICH NM. The challenge of arteriovenous fistula formation following disc surgery: a collective review. *J Trauma* 1976; **16**: 727-733.
- 3 BREWSTER DC, MAY ARL, DARLING RC, ABBOTT WM, MONCURE AC. Variable manifestations of vascular injury during lumbar disc surgery. *Arch Surg* 1979; **114**: 1026-1030.
- 4 MAY ARL, BREWSTER DC, DARLING RC, BROWSE NL. Arteriovenous fistula following lumbar disc surgery. *Br J Surg* 1981; **68**: 41-43.
- 5 QUIGLEY TM, STONEY RG. Arteriovenous fistulas following lumbar laminectomy: the anatomy defined. *J Vasc Surg* 1985; **2**: 828-833.
- 6 NADSTAWEK J, WASSMANN HD, BOKER DK, SCHULTHEISS R, HORNCHEM U. Injuries to the large abdominal vessels during lumbar nucleotomy. *J Neurosurg Sci* 1989; **33**: 281-286.
- 7 CHRISTENSEN C, BANK A. Arteriovenous fistula complicating lumbar disc surgery. *Eur J Surg* 1991; **157**: 145-147.
- 8 SMITH DW, LAWRENCE BD. Vascular complications of lumbar decompression laminectomy and foraminotomy. *Spine* 1991; **16**: 387-390.
- 9 SZOLAR DH, PREIDLER KW, STEINER H et al. Vascular complications in lumbar disc surgery: report of four cases. *Neuroradiology* 1996; **38**: 521-525.
- 10 TSAI YD, YU PC, LEE TC, CHEN HS, WANG SH, KUO YL. Superior rectal artery injury following lumbar disc surgery. Case report. *J Neurosurg* 2001; **95**: 108-110.
- 11 MACHADO-ATIAS I, FORNES O, GONZALEZ-BELLO O, MACHADO-HERNANDEZ I. Iliac arteriovenous fistula due to spinal disc surgery: causes severe hemodynamic repercussion with pulmonary hypertension. *Tex Heart Inst J* 1993; **20**: 60-65.
- 12 BASHKOFF E, GADALETA D, MOCCIO C. Postlaminectomy aortic pseudoaneurysm. *J Spinal Dis* 1992; **5**: 219-221.
- 13 FRUHWIRTH J, KOCH G, AMMAN W, HAUSER H, FLASCHKA G. Vascular complications of lumbar disc surgery. *Acta Neurochir (Wien)* 1996; **138**: 912-916.
- 14 TANAKA M, NAKAHARA S, TANIZAKI M. Aortic pseudoaneurysm in the L3-L4 disc space after lumbar disc surgery. A case report. *J Bone Joint Surg Br* 1998; **80**: 448-451.
- 15 HONG SJ, OH JH, YOON Y. Percutaneous endovascular stent-graft for iliac pseudoaneurysm following lumbar discectomy. *Cardiovasc Intervent Radiol* 2000; **23**: 475-477.
- 16 EWAH B, CALDER I. Intraoperative death during lumbar discectomy. *Br J Anaesth* 1991; **66**: 721-723.
- 17 LESOIN F, WAREMBOURG H, ASSEMAN P. Fatal congestive heart failure associated with an iatrogenic caval aortic fistula following surgical removal of a herniated intervertebral disc. *Surg Neurol* 2000; **53**: 522.
- 18 SALANDER MJ, YOUKEY JR, RICH MN, OLSON WD, CLAGETT GP. Vascular injury related to lumbar disc surgery. *J Trauma* 1984; **24**: 628-631.
- 19 MARKS C, WEINER S, REYDMAN M. Arteriovenous fistula secondary to intervertebral disc surgery. *J Cardiovasc Surg* 1970; **32**: 417-424.
- 20 FRANZINI M, ALTANA P, ANNESSI V, LODINI V. Iatrogenic vascular injuries following lumbar disc surgery. Case report and review of the literature. *J Cardiovascular Surg (Torino)* 1987; **28**: 727-730.
- 21 LINTON R, WHITE PD. Arteriovenous fistula between the right common iliac artery and the inferior vena cava. *Arch Surg* 1945; **50**: 6-13.

- 22 SERRANO HERNANDO FJ, MARTIN PAREDERO V, SOLIS JV *et al.* Iliac arteriovenous fistula as a complication of lumbar disc surgery. *J Cardiovasc Surg* 1986; **27**: 180–184.
- 23 BOLESTA MJ. Vascular injury during lumbar discectomy associated with peridiskal fibrosis: case report and literature review. *J Spinal Dis* 1995; **8**: 224–227.
- 24 FARGALLY M, CHRISTENSON JT. Combined aortic and inferior vena cava injury during laminectomy. A serious complication. *Vasa* 1988; **17**: 288–292.
- 25 VILLANO M, GANTATORE G, NARCISE N, SANTILL F, BIFANO D, CERILLO A. Vascular injury related to lumbar disc surgery. *Neurochirurgia* 1992; **35**: 57–59.
- 26 ANDA S, AAKHUS S, OVE SKAANES K, SANDE E, SCHRADER H. Anterior perforations in lumbar discectomies. A report of four cases of vascular complications and a CT study of the prevertebral lumbar anatomy. *Spine* 1991; **16**: 54–60.
- 27 RAPIS S, QUIGLEY F, BARKER S. Vascular complications of elective lower lumbar disc surgery. *Aust N Z J Surg* 1994; **64**: 216–219.
- 28 STAAB RC, STOEVEER WW, BALDWIN W, HICKMAN L. Arteriovenous fistula complicating lumbar disc surgery: Report of a case. *J Am Osteopath Assoc* 1968; **67**: 1379–1381.
- 29 SANDE E, MYHRE HO, WITSOE E, LUNDBOM J, STOLT-NIELSEN A, ANDA S. Vascular complications of lumbar disc surgery. *Eur J Surg* 1991; **157**: 141–143.
- 30 DULA JD, FIERRO R, GESSNER H, SNOVER SW. Vascular injury following disc surgery. *Am J Emerg Med* 1986; **4**: 406–408.
- 31 DUQUE AC, MERLO I, JANEIRO MJ, MADEIRA EN, PINTO-RIBEIRO R. Postlaminectomy arteriovenous fistula: the Brazilian experience. *J Cardiovasc Surg (Torino)* 1991; **32**: 783–786.
- 32 FREISCHLAG AJ, SISE M, QUINONES-BALDRICH JW, HYE JR, SEDWITZ MM. Vascular complications associated with orthopedic procedures. *Surg Gynecol Obs* 1989; **169**: 147–152.
- 33 SHREIBER MH, WOLMA FJ, MORRETIN LB. Angiographic findings in arteriovenous fistulas following lumbar disc surgery. *Amer J Roentgenol* 1967; **101**: 957–960.
- 34 BUERGER T, MEYER F, TAUTENHAHN J, HALLOUL Z, FAHLKE J. Percutaneous treatment of rare iatrogenic arteriovenous fistulas of the lower limbs. *Int Surg* 1998; **83**: 198–201.
- 35 BIALY T, GOOCH AS, SHAHRIARI A. High-output congestive failure due to arteriovenous fistula resulting from lumbar disc surgery – A case report. *Angiology* 1988; **7**: 616–619.
- 36 STAPLE TW, FRIEDENBERG MJ. Ilio-ilac arteriovenous fistula following intervertebral disc surgery. *Clin Radiol* 1965; **16**: 248–250.
- 37 WAJSZCZUK WJ, MOWRY FM, WHITCOMB JG. Arteriovenous fistula – A complication of surgery of intervertebral disc. *Rocky Mt Med J* 1969; **66**: 37–39.
- 38 SANTOS E, PERAL V, AROCA M *et al.* Arteriovenous fistula as a complication of lumbar disc surgery: case report. *Neuroradiology* 1998; **40**: 459–461.
- 39 SMITH RF, KILLEN DA. Arteriovenous fistula and chronic congestive heart failure following intervertebral disc surgery. *South Med J* 1973; **66**: 1301–1303.
- 40 SAGDIC K, OZER ZG, SENKAYA I, TURE M. Vascular injury during lumbar disc surgery. Report of two cases; a review of the literature. *Vasa* 1996; **25**: 378–381.
- 41 JOHNSRUDE IS, BOGEY WM Jr, TRIPP MD. Postlaminectomy arteriovenous fistula masked by stenosis of the inferior vena cava. *Cardiovasc Intervent Radiol* 1994; **17**: 336–338.
- 42 DAVIES JMC. Ilio-iliac arteriovenous fistula following laminectomy. *Clin Radiol* 1969; **20**: 103–104.
- 43 BENZEL EC. Vascular injury. *J Neurosurg* 2001; **95**: 152.
- 44 KELLY JJ, REUTER KL, WAITE RJ. Vascular injury complicating lumbar discectomy: CT diagnosis, a case report. *Am J Radiol* 1989; **153**: 1233–1234.
- 45 LEE KH, PARK JH, CHUNG JW, HAN JK, SHIN SJ, KANG HS. Vascular complications in lumbar spinal surgery: percutaneous endovascular treatment. *Cardiovasc Intervent Radiol* 2000; **23**: 65–69.
- 46 THOMPSON JA, GLAUSER FL. Postlaminectomy arteriovenous fistula suspected by bed-side data from right side heart catheterization. *Arch Inter Med* 1980; **140**: 1168–1169.
- 47 ALVAREZ HJ, CAZAREZ JC, HERNANDEZ A. An alternative repair of major vascular injury inflicted during lumbar disc surgery. *Surgery* 1986; **101**: 505–507.
- 48 STOKES JM. Vascular complications of disc surgery. *J Bone Joint Surg* 1968; **50**: 394–399.
- 49 GOROMBAY Z, GOMORY A, BEKASSY MS. Iatrogenic aortocaval fistula secondary to intervertebral disc surgery. *Acta Chir Scand* 1984; **150**: 585–587.
- 50 FLETCHER JP, KLINEBERG PL, HAWKER FH *et al.* Arteriovenous fistula following lumbar disc surgery – the use of total cardiopulmonary bypass during repair. *Aust NZ J Surg* 1986; **56**: 631–663.
- 51 HILDRETH DH, TURCKE DA. Postlaminectomy arteriovenous fistula. *Surgery* 1977; **5**: 512–520.
- 52 BIASI GM. Aortocaval fistula: a challenge for endovascular management. *J Endovasc Surg* 1999; **6**: 378.
- 53 LAU LL, O'REILLY MJG, JOHNSTON LC, LEE B. Endovascular stent-graft repair of primary aortocaval fistula with an abdominal aortoiliac aneurysm. *J Vasc Surg* 2001; **33**: 425–428.
- 54 LINDBLAD B, IVANCEV K, CHUTER TAM, MALINA M, BRUNKWALL J, RISBERG B. Endovascular exclusion of juxtarenal anastomotic pseudoaneurysm. *Eur J Surg* 1996; **12**: 116–118.
- 55 BRITTENDEN J, GILLESPIE I, MCBRIDE K, MCINNES G, BRADBURY AW. Endovascular repair of aortic pseudoaneurysms. *Eur J Vasc Endovasc Surg* 2000; **19**: 82–84.
- 56 MOORE CA, COHEN A. Combined arterial, venous and ureteral injury complicating lumbar disc surgery. *Amer J Surg* 1968; **115**: 574–577.
- 57 RISBERG B, LONN L. Management of vascular injuries using endovascular techniques. *Eur J Surg* 2000; **166**: 196–201.
- 58 BAKER KJ, REARDON RP, REARDON JM, HEGGENESS HM. Vascular injury in anterior lumbar surgery. *Spine* 1993; **18**: 2227–2230.
- 59 SILDINO RM, WHITE AA, PALUMBINSKAS AJ. Arteriovenous fistula, a complication of lumbar disc surgery. *Radiology* 1971; **98**: 565–567.
- 60 FALLAHNEJAD M, BOLAND BJ, CHAIT A. Aortoiliac arteriovenous fistula simulating iliac vein thrombosis following intervertebral disc surgery. *Can J Surg* 1983; **26**: 366–367.
- 61 TEH A, JEYAMALAR R, HABIB ZA. Arteriovenous fistula simulating deep venous thrombosis as a complication of lumbar disc surgery. *Med J Malaysia* 1993; **48**: 440–442.
- 62 HOLSCHEER EC. Vascular and visceral injuries during lumbar disc surgery. *J Joint Bone Surg* 1968; **50**: 383–399.
- 63 MCCARTER DHA, JOHNSTONE RD, MCINNES, GC, REID DB, POLLOCK JG, REID AW. Iliac arteriovenous fistula following lumbar disc surgery treated by percutaneous endoluminal stent grafting. *Br J Surg* 1996; **83**: 796–797.
- 64 BRUNKWALL J, LINDBLAD B, IVANCEV K, EMTESJO G, RISBERG B. Iatrogenic AV-fistula treated by a graft-covered self-expandable stent. *Eur J Vasc Endovasc Surg* 1996; **12**: 243–245.
- 65 PARODI JC, SCHONHOLZ C, FERREIRA LM, BERGAN J. Endovascular stent-graft treatment of traumatic arterial lesions. *Ann Vasc Surg* 1999; **13**: 121–129.
- 66 VRAUX H, VERHELST R, HAMMER F, GOFFETTE P. Endovascular repair of iliac aneurysms following aortoiliac surgery. *Eur J Vasc Endovasc Surg* 1998; **17**: 442–445.
- 67 SHEVLIN WA, LUESSENHOP AJ, FOX JL, MCCULLOUGH DC. Perforation of the anterior annulus during lumbar discectomy. Case report. *J Neurosurg* 1973; **38**: 514–515.
- 68 GOODKIN R, LASKA LL. Vascular and visceral injuries associated with lumbar disc surgery: medicolegal implications. *Surg Neurol* 1998; **49**: 358–372.

Accepted 20 April 2002